§23. Observation of Fluctuation Generated by Energetic Particles and Electrons Using Microwave Reflectometer

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Two reflectometer systems are utilized for fluctuation measurements. Using the extraordinary polarized wave, we can measure the corresponding value to the combined fluctuation with the electron density and the magnetic field in the plasma core region.

One system has 4 channels of fixed frequencies of 78, 72, 68, and 65 GHz. This system is very convenient to observe MHD phenomena such as energetic particle driven Alfvén eigenmodes. Another system is consisted by a VCO which is the frequency changeable source. The source frequency is swept full range (26 – 40GHz) every 200ms and the number of the stair step is 20. Each time of the launching frequency is 10ms and data sampling rate is 1μs, then the data point is 10,000 and the frequency resolution is 100Hz. It is also enough to observe the MHD phenomena such as TAE. Figure 1 shows the frequency spectrum of the frequency fixed 78GHz reflectometer signal. In this plasma condition that the axial magnetic field strength is 1.0 T and the averaged electron density is under $0.5\times10^{19}m^{-3}$, there is no cut-off layer of 78GHz and this system is operated as an interferometer mode. We can see several continuous coherent frequency components. Figure 2 shows the radial profile of the fluctuation strength of the frequency swept reflectometer signal during t=4.0-4.8s (4 periods). It can be obtained that the frequency component around 200kHz is large near at ρ=0.8 and the other component around 150kHz is localized in the plasma core. Here the meaning of the data points which are located under ρ=0 is that these frequency waves are not reflected from the plasma and they are come back from the opposite wall.

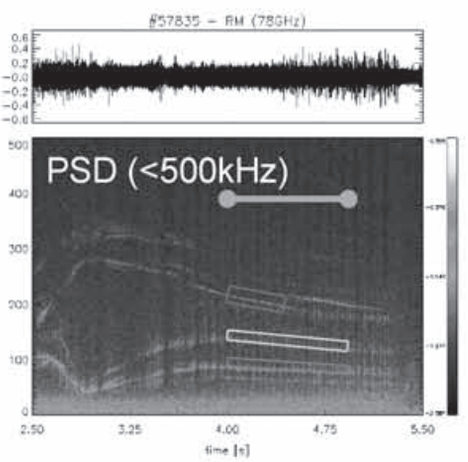

Fig. 1. Frequency spectrum of interferometer mode CW Reflectometer.

Non-thermal electrons have been seen to leads the energy quench in several tokamaks. Also, in LHD it is observed that the high power ECH generates the high energy electrons measured by HX-NPA. In such discharges, the fluctuation with coherent spectra of around 10 kHz is observed in reflectometer signal as shown in Fig. 2. Here an additional ECH is injected after 0.75s. The characteristics of this phenomenon need the future study.

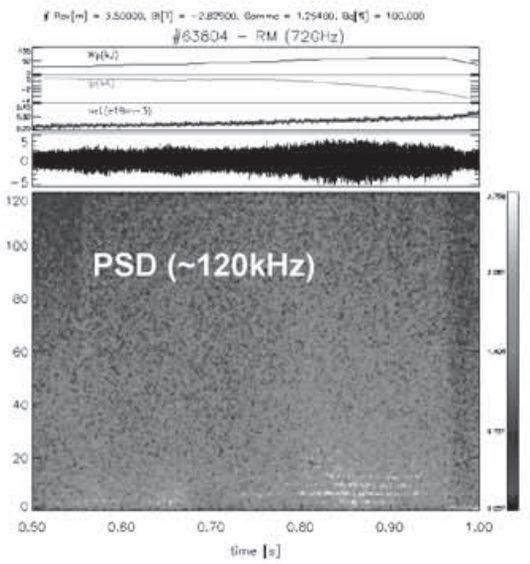

Fig. 3. Temporal evolution of frequency spectrum of 72 GHz reflectometer signal.

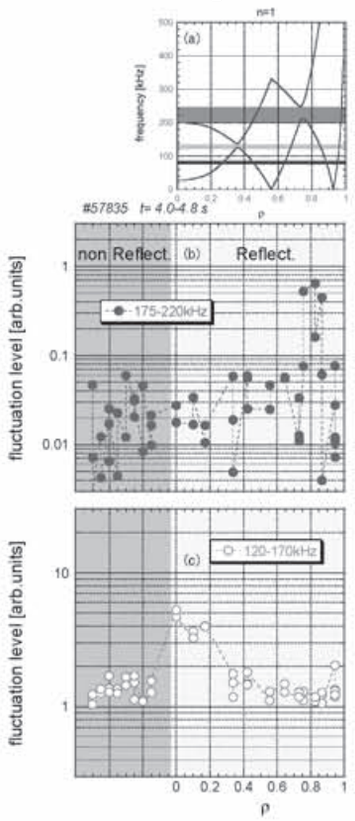

Fig.2. (a) Shear Alfvén spectra for n=1 and Radial profile of the fluctuation component of FM-CW reflectometer in the range that (b) 175-220 kHz and (c) 120-170kHz.